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(54) Title: DIFFERENTIATED SERVICES PROVISIONING FOR LEGACY SYSTEMS

(57) Abstract: In a packet switched communications system that supports per-hop-behavior differentiated services, an edge packet switched node (32) examines a class of service (CoS) designation requested for a packet (50) to determine if special differentiated service (56) is desired for the packet. If so, the node bypasses the normal per-hop-behavior forwarding mechanism for supporting differentiated services in favor of the initiation of a service providing a dedicated end-to-end path through the system for handing the packet and providing a guaranteed level of quality of service. For instance, with respect to operation within a legacy asynchronous transfer mode (ATM) system, internet protocol (IP) packets or multiple protocol label switching (MPLS) packets may specify a special differentiated service comprising a constant bit rate (CBR) service. In each case, the edge legacy ATM node receiving the packet reads the header to identify that constant bit rate service is being requested, and bypasses the normal per-hop-behavior forwarding mechanism for providing differentiated services in favor of the initiation of a native ATM constant bit rate service.

DIFFERENTIATED SERVICES PROVISIONING FOR LEGACY SYSTEMS

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to packet switched communications systems and, in particular, to the support of differentiated services provisioning within such systems.

Description of Related Art

Reference is now made to FIGURE 1 wherein there is shown a block diagram of a communications system 6 implementing a prior art differentiated services provisioning model. Differentiated services defines some significant characteristics of packet transmission in one direction across a set of one or more paths through the system 6. These characteristics may be specified in quantitative or statistical terms of throughput, delay, jitter, and/or loss, and may otherwise be specified in terms of some relative priority of access to network resources for the purpose of conveying packets through the system 6. The system 6 comprises a transaction control protocol (TCP) over internet protocol (IP) communications system comprised of a plurality of network interconnected IP nodes 8. The system 6, through its interconnected nodes 8, supports the provision of differentiated services utilizing the concept of per-hop-behavior (PHB). As a packet of data passes (i.e., hops) from node 8 to node, each successively implicated node in the path examines a class of service (CoS) designation requested for the packet, and then attempts, with respect to the next attempted hop in the path, to provide that requested class of service. Put another way, differentiated services are realized by mapping the class of service designation (i.e., a codepoint) contained within the IP header to a particular packet forwarding treatment (or per-hop-behavior) at each node 8 along the utilized path. Three known per-hop-behavior mechanisms comprise a default behavior (best efforts), an assured forwarding behavior and an

expedited forwarding behavior. The default behavior standardizes the default quality of service (QoS) available in the prior art. Such a best effort behavior has no traffic contract, so the handled traffic gets whatever bandwidth is left over after other per-hop-behavior handled packets have been forwarded on to the next node. Assured forwarding delivers a guaranteed sustained rate, with bursts up to a defined maximum. An input policing mechanism marks the burst packets and out-of-contract packets with different values within the differentiated services field so that these packets can be dropped in the event of congestion. In this context, burst packets allow statistical multiplexing (like a variable bit rate ATM service) without requiring rigorous end-to-end traffic engineering to guarantee bandwidth and delay. Expedited forwarding delivers guaranteed bandwidth, delay and packet loss based on ATM constant bit rate-like traffic engineering. An input policing mechanism drops all out-of-contract packets at ingress to the system and packets are shaped at egress. With this behavior, a virtual leased line service is enabled that delivers the benefits of a traditional leased line guaranteed bandwidth and minimal delay, but at a lower cost because it is carried over the shared IP network. This means that unused bandwidth resources are passed on to other applications and cannot be regained in real time. Unfortunately, for such known per-hop-behavior mechanisms, performance (e.g., timeliness) cannot be guaranteed because priority scheduling considerations are evaluated at each node (for the next hop) with respect to each packet, and thus there can be no quality of service (QoS) assurances given to the system user with respect to the transit handling of their data communications. In such systems, it may be impossible to support the handling of real-time or near real-time communications (such as, for example, voice data for cellular mobile telephone calls).

It is apparent that users, and especially real-time or near real-time users, would prefer to receive assurances relating to quality of service. It is also apparent that a system capable of supporting class of service requests without also providing quality of service is unlikely to draw general user acceptance with respect to the handling of

real-time or near real-time communications. What is needed then is a mechanism capable of operation within legacy per-hop-behavior packet switched systems that is responsive to class of service requests while simultaneously providing hard quality of service.

SUMMARY OF THE INVENTION

In a packet switched communications system that supports per-hop-behavior differentiated services, an edge packet switched node examines a class of service (CoS) designation requested for the packet to determine if special differentiated service is desired for the packet. If so, the node bypasses the normal per-hop-behavior forwarding mechanism for supporting differentiated services in favor of the initiation of a service providing a dedicated end-to-end path through the system for handing the packet and providing a guaranteed level of quality of service.

More particularly, the packet switched communications system comprises a legacy asynchronous transfer mode (ATM) system supporting per-hop-behavior differentiated service. Internet protocol (IP) packets transmitted through the system for which special differentiated service is requested include, for instance, a differentiated services field in each header specifying a request for constant bit rate (CBR) service. An edge legacy ATM node receiving the packet reads the header to identify that constant bit rate service is being requested, and bypasses the normal per-hop-behavior forwarding mechanism for providing differentiated services in favor of the initiation of a native ATM constant bit rate service.

Still further, the packet switched communications system supports multiple protocol label switching (MPLS) at each legacy ATM node. Internet protocol (IP) packets transmitted through the system are encapsulated within an MPLS packet that includes a shortened header. The information contained within a differentiated services field of the IP header specifying the request for constant bit rate service (i.e., special differentiated services) is exported to the shortened MPLS header. An edge

legacy ATM node receiving the packet reads the shortened MPLS header to identify that constant bit rate service is being requested, and bypasses the normal per-hop-behavior forwarding mechanism for providing differentiated services in favor of the initiation of a native ATM constant bit rate service.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be acquired by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

FIGURE 1, previously described, is a block diagram of a communications system implementing a prior art per-hop-behavior differentiated services provisioning model;

FIGURE 2 is a block diagram of a client/server environment wireless communications network in accordance with the present invention;

FIGURE 3 is a format diagram for an IP packet;

FIGURE 4 is a flow diagram for edge router operation in accordance with the present invention;

FIGURE 5 is a format diagram for a multiple protocol label switching (MPLS) packet; and

FIGURE 6 is a flow diagram for edge router operation in accordance with alternative embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is now made to FIGURE 2 wherein there is shown a block diagram of a client/server environment wireless communications network in accordance with the present invention. In providing wireless communications services, the clients 10 comprise a plurality of base stations 12 that support subscriber communications over an air interface 14 with a plurality of mobile stations 16. The server 18 comprises a

mobile switching center 20 having functionalities for network signaling and control 22, gateway operations 24 for interfacing the network to the Internet or an intranet, and service provision 26 for supporting subscriber access to services such as, for example, voice mail, intelligent networking (IN), and the like. Interconnecting the clients 10 to the server 18 is a legacy packet switched core network 30 comprised of a plurality of edge routers 32 supporting connections to the base stations 12 and the mobile switching center 20, and a plurality of switch routers 34 that are interconnected 36 in at least an almost fully-meshed network configuration. Some of the switch routers 34 support connections to the edge routers 32.

The edge routers 32 and switch routers 34 of the core network 30 comprise packet switched nodes implementing a legacy switching technology (such as, for example, asynchronous transfer mode (ATM), giga-byte routers, IP-over-WDM routers, and the like) at OSI layer 2. Communication over the network 30 utilizes transaction control protocol (TCP) or user datagram protocol (UDP) over internet protocol (IP) at OSI layer 3. The physical (PSY) connection between the nodes provided by OSI layer 1 may comprise any suitable connection such as, for example, fiber optics, microwave links, coaxial cable, and the like.

Each of the routers 32 and 34 supports conventional prior art (see, FIGURE 1) provisioning of differentiated services utilizing the concept of per-hop-behavior (PHB) provided through IP at OSI layer 3. More specifically, the routers 32 and 34 process each IP packet (at each hop from node to node) by examining a class of service (CoS) designation requested for the packet. The routers 32 or 34 then attempt, with respect to the next attempted hop in a path, to provide that requested class of service. The routers 32 and 34 may implement any known per-hop-behavior mechanisms including either a default behavior (best efforts), assured forwarding, or an expedited forwarding behavior. Handling of packets and the provisioning of differentiated services in this manner provides satisfactory performance with respect to conventional data communications (such as file transfers and browsing). However, these per-hop-

behavior mechanisms disadvantageously evaluate priority scheduling considerations at each router. These evaluations introduce resource limitations and delays in through transit of the data, and as a result, performance (e.g., timeliness) cannot be guaranteed and no quality of service (QoS) assurances can be given to the system user with respect to the transit handling of their data communications. It may then be impossible for the system to support differentiated services in connection with the handling of real-time or near real-time communications (such as the voice data for cellular mobile telephone calls with the system of FIGURE 2).

Reference is now made to FIGURE 3 wherein there is shown a format diagram for an IP packet 50. The IP packet 50 includes a header portion 52 and a payload portion 54. The header portion is relatively large (in the order of twenty bytes) and includes a number of pieces of information as is well known in the art. Importantly, in the context of the present invention, the header portion 52 includes a differentiated service field 56 (perhaps occupying the known type of service (ToS) byte within the IP packet header) that in conventional per-hop-behavior (PHB) operation specifies the requested class of service. In the context of the present invention, however, the differentiated service field 56 includes information specifying that the IP packet 50 is to be handled in accordance with special differentiated services (as will be described in more detail below) other than the conventional differentiated services provided through utilization of the prior art concept of per-hop-behavior at IP OSI layer 3. The payload portion 54 contains the user data to be conveyed through the system.

In the event conveyance of the user data is particularly time sensitive, an indication requesting special differentiated services may be inserted within the differentiated service field 56. Examples of the special differentiated services supported by the system (see, FIGURE 2) and that may be specified in the differentiated service field 56 include ATM constant bit rate (CBR) service, real time variable bit rate (RT-VBR), near real time variable bit rate (NRT-VBR), and the like.

When so specified, the system carrying the IP packet 50 attempts to provide the requested service to the exclusion of any other differentiated services mechanism.

Reference is now once again made to FIGURE 2. In an effort to provide differentiated services to time sensitive data communications, each edge router 32 reads the differentiated service field 56 of each received IP packet 50 to determine if special differentiated services have been requested. If so, the router 32 bypasses the normal per-hop-behavior forwarding mechanism for supporting differentiated services at IP OSI layer 3 in favor of the initiation of a service at OSI layer 2 that provides a dedicated end-to-end path through the system for handing the packet with a guaranteed level of quality of service. As an example, assume that the routers 32 and 34 support asynchronous transfer mode (ATM) at OSI layer 2. Responsive to an indication in the differentiated service field 56 of a received IP packet 50 for requested special differentiated services, the edge router 32 bypasses the conventional IP per-hop-behavior forwarding mechanism for supporting differentiated services and initiates native ATM constant bit rate service at OSI layer 2 for delivering the packet through the system. As another example, the routers 32 and 34 provide dedicated label switched paths (LSPs) through the use of reserved label resources space which have be pre-provisioned at these routers strictly for the purpose of assuring hard quality of service.

Reference is now made to FIGURE 4 wherein there is shown a flow diagram for edge router operation in accordance with the present invention. In step 70, the edge router reads the differentiated services field within the received IP packet. If the differentiated services field includes an indication for special differentiated services handling (such as, for example, a request for ATM constant bit rate service), the requested service is initiated by the edge router in step 72 in order to provide a dedicated end-to-end path through the system for handing the packet (and its associated call) with a guaranteed level of quality of service. More specifically, appropriate ATM user-to-network interface (UNI) signaling is invoked. In step 74,

the edge router process waits for a next call, and then returns 76 to step 70 to handle that call as appropriate.

The edge routers 32 and switch routers 34 of the core network 30 shown in FIGURE 2 may, in an alternative embodiment, implement multiple protocol label switching (MPLS). An MPLS packet 80 is illustrated in FIGURE 5. The packet 80 encapsulates an IP packet 50 (see, FIGURE 3). The packet 80 includes a header portion 82 and a payload portion 84. The header portion 82 is relatively small (in the order of four bytes) in comparison to the IP packet header portion 52, and includes a number of pieces of information as is well known in the art. Importantly, in the context of the present invention, the header portion 82 includes a class of service field 86 that contains the information exported from the differentiated service field 56 within the IP packet header. As discussed above, the differentiated services field may specify the use of conventional per-hop-behavior (PHB) operation with respect to the requested class of service. In the context of the present invention, however, the class of service field 86 includes information specifying that the MPLS packet 80 (and hence the included IP packet 50) is to be handled in accordance with special differentiated services (as described herein in more detail) other than the conventional differentiated services provided through utilization of the prior art concept of per-hop-behavior at IP OSI layer 3. The payload portion 84 contains the entire IP packet 50 (including its header and payload portions).

In the event conveyance of the user data is particularly time sensitive, an indication requesting special differentiated services may be inserted within the differentiated service field 56 of the IP packet 50, and exported into the class of service field 86 within the MPLS packet 80. Examples of the special differentiated services supported and that may be specified in the class of service field 86 include ATM constant bit rate (CBR) service, real time variable bit rate (RT-VBR) service, near real time variable bit rate (NRT-VBR) service, and the like. When so specified,

the system (see, FIGURE 2) carrying the MPLS packet 80 attempts to provide the requested service to exclusion of any other differentiated services mechanism.

Reference is now once again made to FIGURE 2. In an effort to provide differentiated services to time sensitive data communications, each edge router 32 reads the class of service field 86 of each received MPLS packet 80 to determine if special differentiated services have been requested. If so, the router 32 bypasses the normal per-hop-behavior forwarding mechanism for supporting differentiated services at IP OSI layer 3 in favor of the initiation of a service at OSI layer 2 that provides a dedicated end-to-end path through the system for handing the packet with a guaranteed level of quality of service. As an example, assume that the routers 32 and 34 implement asynchronous transfer mode (ATM) at OSI layer 2. Responsive to an indication in the class of service field 86 of a received MPLS packet 80 for requested special differentiated services, the edge router 32 bypasses the conventional IP per-hop-behavior forwarding mechanism for supporting differentiated services and initiates native ATM constant bit rate service at OSI layer 2 for delivering the packet through the system. As another example, real time variable bit rate or near real time variable bit rate services may be implemented.

Reference is now made to FIGURE 6 wherein there is shown a flow diagram for edge router operation in accordance with alternative embodiment of the present invention. In step 90, the edge router reads the class of service field within the received MPLS packet. If the class of service field includes an indication for special differentiated services (such as, for example, a request for ATM constant bit rate service), the requested service is initiated by the edge router in step 92 in order to provide a dedicated end-to-end path through the system for handing the packet (and its associated call) with a guaranteed level of quality of service. More specifically, appropriate ATM user-to-network interface (UNI) signaling is invoked. In step 94, the process tests for whether the underlying call with respect to the MPLS packet was already under MPLS control due to pre-provisioning. If yes (path 96), MPLS control

over the label switched path (LSP) is disabled in step 98. If no (path 100), or following disabling in step 98, the process waits for the end of the call and gives control back to MPLS in step 102. In step 104, the edge router process waits for a next call, and then returns 106 to step 90.

As part of conventional label switched path (LSP) establishment, an LSP session is established by a two step process comprising transport connection establishment and session initialization. In accordance with the present invention, however, when the ATM user-to-network (UNI) signaling is invoked, the control over the label switched path by the LDP protocol is disabled (in step 98) by sending an appropriate message to all routers involved in the path. This message signals an advisory information for the state of the frozen LDP session. For example, a freeze-LDP message may initially be sent to each of the nodes to obtain a hard quality of service path from the reserved hard quality of service label space until such time as UNI signaling is terminated. Once the hard quality of service session is over, control is given back to the LDP (see, step 102) by sending an unfreeze-LDP message to all involved routers with respect to the specified label space. At this point, the hard quality of service label space is released for future hard quality of service sessions, and the regular label space is assigned by the LDP protocol.

Although preferred embodiments of the method and apparatus of the present invention have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. A communications system, comprising:

a core network including a plurality of interconnected packet switch routers and a plurality of packet edge routers connected to ones of the packet switch routers;

wherein each router implements a per-hop-behavior forwarding mechanism for supporting differentiated services; and

wherein each edge router further operates to examine a class of service (CoS) designation requested for a received packet to determine if special differentiated service is desired for the packet, and if so bypass the per-hop-behavior forwarding mechanism for supporting differentiated services in favor of the initiation of a service providing a dedicated end-to-end path through the system for handling the packet and providing a guaranteed level of quality of service.

2. The system as in claim 1 wherein the routers comprise asynchronous transfer mode (ATM) routers, and the initiated service comprises ATM constant bit rate (CBR) service.

3. The system as in claim 1 wherein the packet comprises an internet protocol (IP) packet including a header portion having a field containing the class of service designation indicating that special differentiated service is requested.

4. The system as in claim 1 wherein the packet comprises a multiple protocol label switching (MPLS) packet including a header portion having a field containing the class of service designation indicating that special differentiated service is requested.

5. The system as in claim 4 wherein the MPLS packet further includes a payload portion containing an internet protocol packet.

6. The system as in claim 5 wherein the internet protocol packet includes a header portion having a field containing the class of service designation indicating that special differentiated service is requested, and wherein that indication is exported into the header field of the MPLS packet.

7. A communications system, comprising:

a core network including a plurality of interconnected asynchronous transfer mode (ATM) packet switch routers and a plurality of ATM packet edge routers connected to ones of the packet switch routers;

wherein each router implements a per-hop-behavior forwarding mechanism for supporting differentiated services; and

wherein each edge router further operates to examine a class of service (CoS) designation requested for a received packet to determine if constant bit rate service is desired for the packet, and if so bypass the per-hop-behavior forwarding mechanism for supporting differentiated services in favor of the initiation of an ATM constant bit rate service for handling the packet and providing a guaranteed level of quality of service.

8. The system as in claim 7 wherein the packet comprises an internet protocol (IP) packet including a header portion having a field containing the class of service designation indicating requested constant bit rate service.

9. The system as in claim 7 wherein the packet comprises a multiple protocol label switching (MPLS) packet including a header portion having a field containing the class of service designation indicating requested constant bit rate service.

10. The system as in claim 9 wherein the MPLS packet further includes a payload portion containing an internet protocol packet.

11. The system as in claim 10 wherein the internet protocol packet includes a header portion having a field containing the class of service designation indicating requested constant bit rate service, and wherein that indication is exported into the header field of the MPLS packet.

12. A method for packet edge router operation in providing differentiated services wherein the packet edge router implements a per-hop-behavior forwarding mechanism for supporting differentiated services, comprising the steps of:

reading a class of service (CoS) designation within a received packet;

determining if the class of service designation indicates special differentiated services handling; and

if so, bypassing the per-hop-behavior forwarding mechanism for supporting differentiated services in favor of the initiation of a service providing a dedicated end-to-end path through the system for handling the packet and providing a guaranteed level of quality of service.

13. The method as in claim 12 further including the step of initiating an asynchronous transfer mode (ATM) constant bit rate (CBR) service.

14. The method as in claim 12 wherein the packet comprises an internet protocol (IP) packet including a header portion having a field containing the class of service designation indicating that special differentiated service is requested.

15. The method as in claim 12 wherein the packet comprises a multiple protocol label switching (MPLS) packet including a header portion having a field

containing the class of service designation indicating that special differentiated service is requested.

16. The method as in claim 15 further including the steps of:

determining whether a call associated with the MPLS packet is already under MPLS control due to pre-provisioning; and

if yes, disabling MPLS over a label switch path for that call.

17. The method as in claim 16 wherein the step of disabling comprises the step of signaling each router in the label switch path in order to specify a hard quality of service path from reserved hard quality of service label space.

18. A method for asynchronous transfer mode (ATM) packet edge router operation in providing differentiated services wherein the packet edge router implements a per-hop-behavior forwarding mechanism for supporting differentiated services, comprising the steps of:

reading a class of service (CoS) designation within a received packet;

determining if the class of service designation indicates a request for ATM constant bit rate service; and

if so, bypassing the per-hop-behavior forwarding mechanism for supporting differentiated services in favor of the initiation of ATM constant bit rate service for handing the packet and providing a guaranteed level of quality of service.

19. The method as in claim 18 further including the step of initiating the asynchronous transfer mode (ATM) constant bit rate (CBR) service.

20. The method as in claim 18 wherein the packet comprises an internet protocol (IP) packet including a header portion having a field containing the class of service designation that constant bit rate service is requested.

21. The method as in claim 18 wherein the packet comprises a multiple protocol label switching (MPLS) packet including a header portion having a field containing the class of service designation that constant bit rate service is requested.

22. The method as in claim 21 further including the steps of:

determining whether a call associated with the MPLS packet is already under MPLS control due to pre-provisioning; and

if yes, disabling MPLS control over a label switched path for that call.

23. The method as in claim 22 wherein the step of disabling comprises the step of signaling each router in the label switch path in order to specify a hard quality of service path from reserved hard quality of service label space.

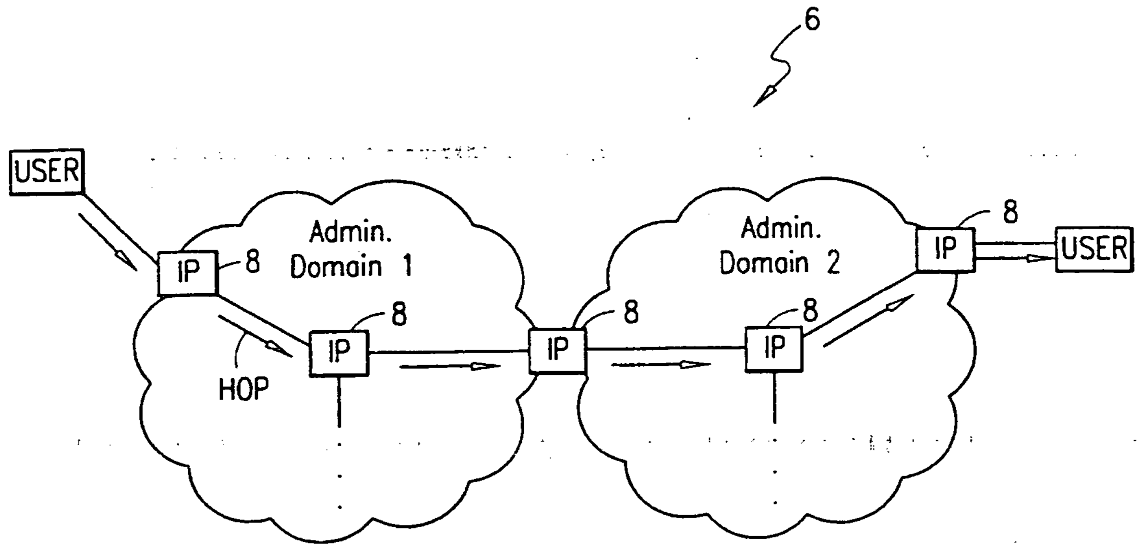
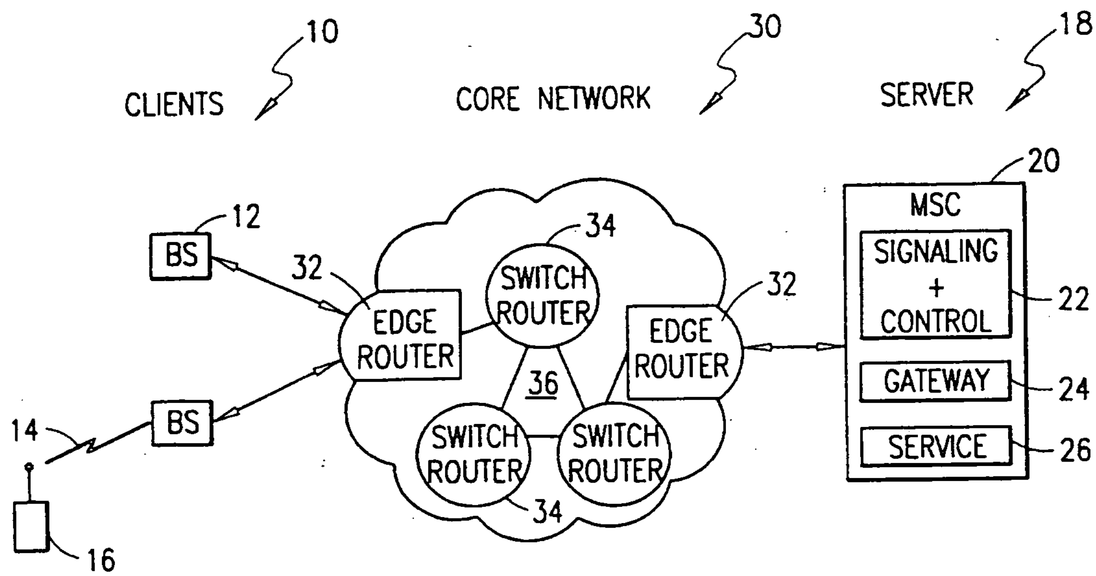

6
USER
Admin.
Domain 1
IP
8
HOP
IP
8
IP
8
Admin.
Domain 2
IP
8
IP
8
USER

FIG. 1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CLIENTS
30
CORE NETWORK
18
SERVER
20
MSC
SIGNALING + CONTROL
22
GATEWAY
24
SERVICE
26
12
BS
32
EDGE ROUTER
34
SWITCH ROUTER
36
SWITCH ROUTER
SWITCH ROUTER
34
32
EDGE ROUTER
BS
14
16

FIG. 2

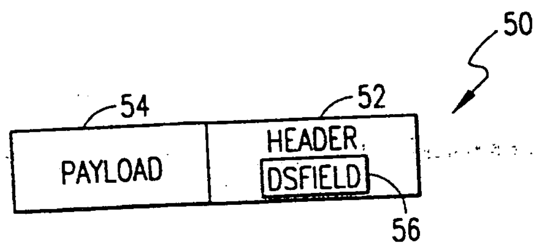


FIG. 3

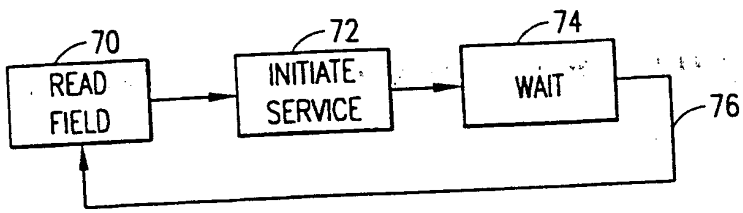


FIG. 4

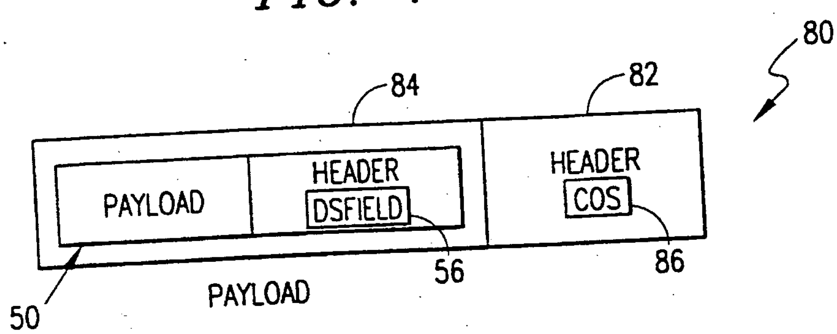


FIG. 5

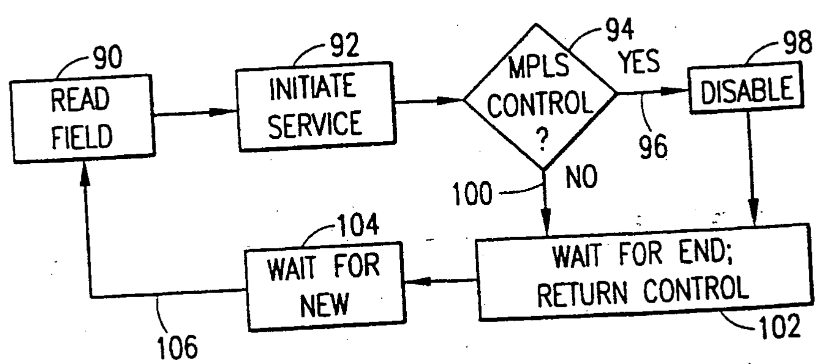
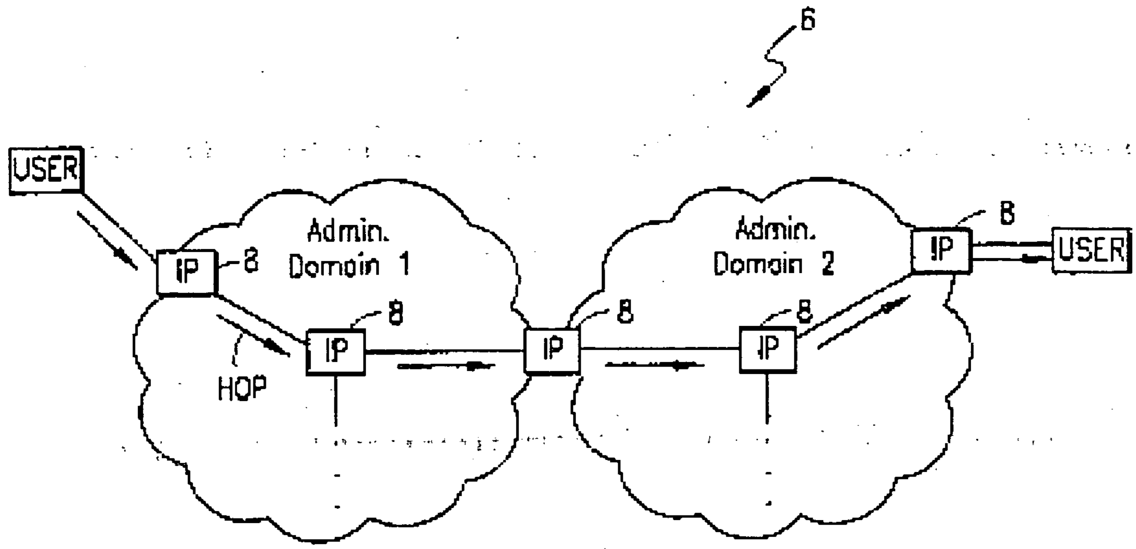


FIG. 6


6
USER
IP
8
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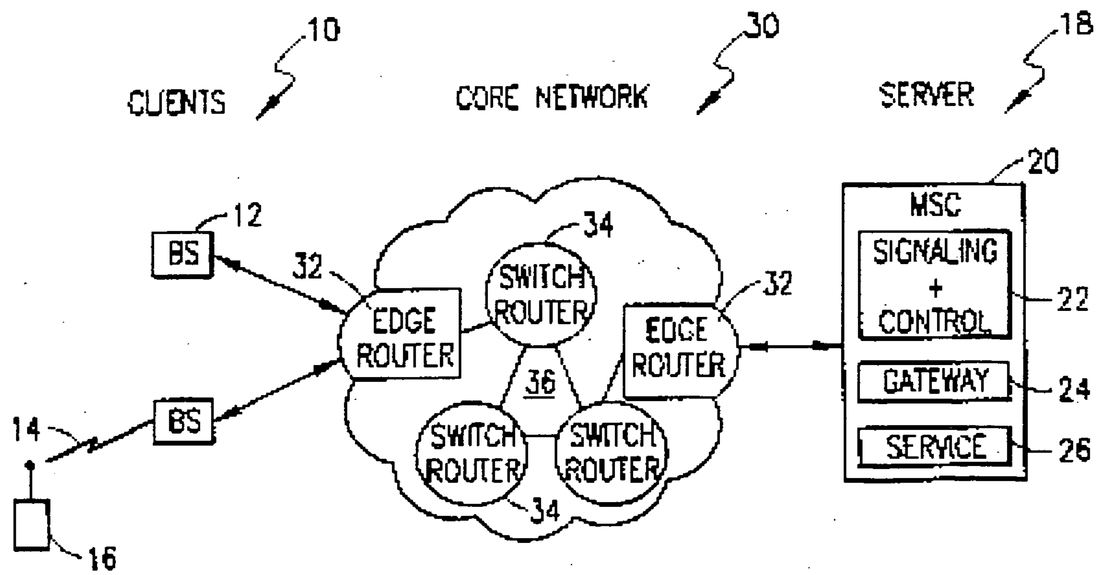
Domain 1
8
IP
HOP
IP
8
Admin.
Domain 2
IP
8
IP
8
USER

FIG. 1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CLIENTS
30
CORE NETWORK
18
SERVER
BS
12
32
EDGE ROUTER
34
SWITCH ROUTER
36
SWITCH ROUTER
SWITCH ROUTER
34
32
EDGE ROUTER
14
BS
16
20
MSC
SIGNALING + CONTROL
22
GATEWAY
24
SERVICE
26

FIG. 2

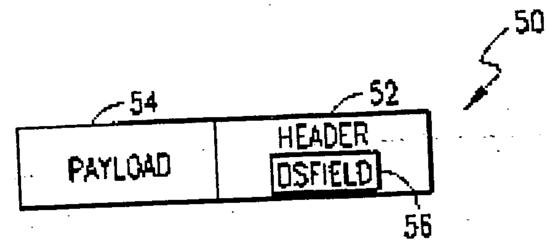

FIG. 3

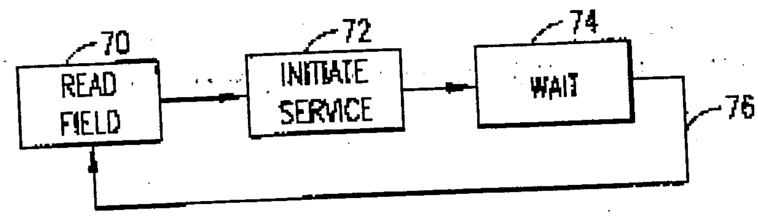

FIG. 4

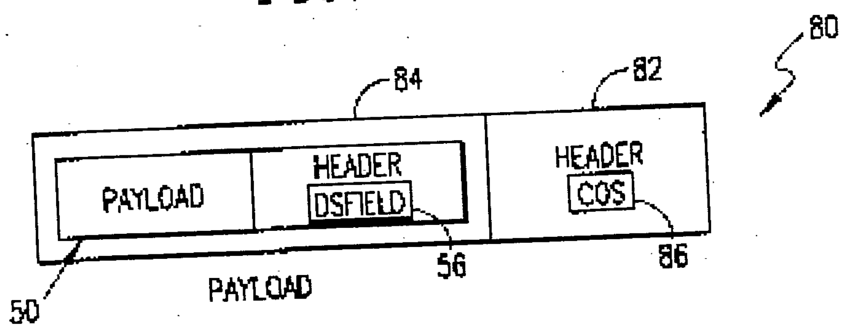

FIG. 5

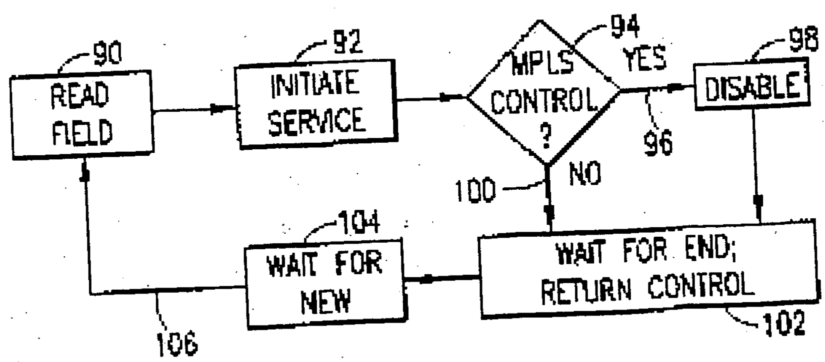

FIG. 6